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Original Article

ASSESSING THE WATER QUALITY OF JAKARA DAM, KANO-NIGERIA BY THE USE OF MACRONIVERTEBRATES

***[1]Ibrahim, S. and [2]Ibrahim, A. A.**

[1]Department of Biological Sciences, Bayero University, Kano, Kano State
[2]Department of General Studies, College of Administrative and Business Studies, Potiskum, Yobe State.

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ABSTRACT

A study on the water quality assessment of Jakara Dam was conducted from January to October 2016 at 4 studied sites, using Biological Monitoring Working Party (BMWP) Score and Average Score Per Taxa (ASPT) assessment tools. Using standard technique, a total of 10631 macroinvertebrates belonging to three phyla; Mollusca, Arthropoda, and Annelida and comprising of 15 families were collected and identified. BMWP Score and ASPT values obtained were recorded for each site (A, B, C and D) during the sampling period. The results revealed that all the sites had poor water quality with BMWP score less than 100 and ASPT value less than 4. Gastropod (*Melanoides tuberculata*), dipteran larvae (*Chironomus* sp.), and annelid worm (*Tubifex tubifex*) were the dominant species identified during the sampling period. The presence of pollution indicator species such as *Melanoides tuberculata*, *Chironomus* sp. *Hirudo medicinalis* and *Tubifex tubifex* confirmed that Jakara Dam is polluted. It was therefore recommended that further studies should be done to validate the use of BMWP/ASPT score as indices of organic pollution.

Keywords: Water quality, assessment, macroinvertebrates, Jakara Dam, BMWP, ASPT

***Correspondence author**: Ibrahimadoadamu02@gmail .com +23408065116617

INTRODUCTION

Water is the basis of all life and primary need for all life processes. With increasing industrialization and population growth, water sources available for various purposes such as drinking, recreation, agriculture and aquaculture have been adulterated with industrial as well as animal and domestic wastes. As a result, it has become the most important means of transmission of several infectious diseases (Aneja, 2005). Polluted sewage contains solid and dissolved organic compounds that impact on offensive odour and serves as excellent medium for growth and multiplication of macro-and microorganisms (Aneja, 2005). Invertebrate communities change in response to changes in physicochemical factors and available habitats. The biotic structure and water quality of lakes and rivers reflect an integration of the physical, chemical and anthropogenic processes occurring in a catchment area, leading to the concept of ecological integrity (Chatzinikolauo *et al.,* 2006). Macroinvertebrates are ubiquitous and diverse group of long lived species that react strongly and often predictably to human influences in aquatic ecosystem. In addition they are sedentary; therefore body burdens reflect local conditions, allowing detection of a variety of perturbations in a range of aquatic habitats (Rosenberg and Resh, 1993). Biomonitoring studies and use of macroinvertebrates to assess the quality of water bodies which include both lotic and lentic types have been widely reviewed (Ogbeibu and Oribhabor, 2002; Imoobe and Ohiozebau, 2009; Omoigberale and Ogbeibu, 2010; Olomukoro and Dirisu, 2012; Arimoro and Keke, 2017) in Nigeria. Bio-survey involves collecting, processing and analyzing organisms to determine the health of the biological community in a water body. The three most common biological organisms studied in relation to pollution are fish, algae and macroinvertebrates (De Pauw *et al*., 2006). Chemical water tests are limited because they only tell what is in the water at the specific moment the sample was collected. They do not give an indication of what was in the water an hour ago, yesterday or last week. If pollutants were in the water last week or yesterday, the quality and diversity of macroinvertebrates present would reflect this in water quality (Iliopoulou-Georgudaki *et al.,* 2003).

The Biological Monitoring Working Party (BMWP) score system, is one of the most common biotic indices in use and has been applied to various streams, rivers and lakes throughout Europe and the world at large (Roche *et al.,* 2010). This index allocates a single score to macroinvertebrates at the family level that is representative of the family's tolerance to water pollution; the greater their tolerance, the lower the BMWP score and *vice versa* (Armitage *et al.,* 1983). BMWP score is not specific to any single river catchment or geographical area, it has been standardized by the International Organization for Standardization (IOS). It can be used to reflect the impact of organic pollution. The purpose of this study is to determine the water quality of Jakara Dam via macroinvertebrates using BMWP score and Average Score Per Taxa (ASPT) as assessment tools, so that this study could be a reference archive for future studies.

MATERIALS AND METHODS

Study Area

The study was conducted at Jakara Dam that was impounded in 1976. The major tributaries of the Dam are River Jakara and River Geshi which receives most of Kano City's domestic and industrial waste water. The Dam lies between longitude $8^{o}31'$ to $8^{o}45'$E and latitude $20^{o}13'$ $12^{o}10'$N in Wasai, a village in Minjibir local government area of Kano State, about 41.5km from city centre (Badamasi, 2014). The water body contains muddy substratum and flows gently. The turbidity of the water is low and it has rich growth of algae and macrophytes (Duwa and Oyeyi, 2009).

Sampling Points/Sites

Four sampling points were chosen and designated A, B, C and D. Site A is close to Dinga village; effluents flow directly to this point from Dinga village. Site B is associated with agricultural activities. At Site C laundry activities is common and at site D fishing activities is prominent.

Collection, Counting and Identification of Macroinvertebrates

Samples were collected fortnightly from January to October 2016 using standard wooden handle 1mm mesh size net. Samples were emptied into a white opaque tray to remove large pieces of organic debris or stones from the sample and emptied in to a suitable, labeled container and preserved with 70% alcohol (Chapman and Jackson, 1996). The water bed was scooped for benthic macroinvertebrates using improvised Ekman grab as described by Maitland (1978). The mud samples were then emptied into a polythene bags and transported back to laboratory. The mud samples were then separately put in to a sieve (0.05mm net size) and added water and shaken. The mud content was moved down leaving the macroinvertebrates on the sieve. The macroinvertebrates were further sorted on a petri dish in the laboratory and identified to species level using the identification keys described by Pawley (2011) and Dobson *et al.* (2012).

Sample Analysis

Samples were analyzed by allocating a score between 1 and 10 to each group or family according to their sensitivity to environmental disturbance (Bartram and Balance, 1996). In order to reduce the effects of sample size, sampling effort and sampling efficiency on the results obtained by this method, the Average Score Per Taxa (ASPT) was also be taken into consideration. This is obtained by dividing the BMWP Score by the total number of families in the sample. A BMWP score greater than 100 together with an ASPT value greater than 4, generally indicates good water quality (Bartram and Balance, 1996). ASPT values for each site were obtained and recorded following Bartram and Balance (1996) evaluation technique below

$$\text{ASPT} = \frac{\text{summation of BMWP Scores}}{\text{Total number of families in the sample}}$$

The data obtained from BMWP and ASPT score were subjected to one way Analysis of Variance (ANOVA), using Statistical Package for Social Science (SPSS) version 15.50 to test the difference in BMWP scores and ASPT values. P-values ≤ 0.05 were considered statistically significant.

Table 1: The Biological Scores Allocated to Macroinvertebrates by the Biological Monitoring Working Party (BMWP) score

Score	Families of Macroinvertebrate
10	Siphlonuridae, Heptageniidae, Leptophlebiidae, Ephemerellidae, Potamanthidae, Ephemeridae,Taeniopterygidae, Leuctridae, Capniidae, Perlodidae, Perlidae, Chloroperlidae Aphelocheiridae Phryganeidae, Molannidae, Beraeidae, Odontoceridae, Leptoceridae, Goeridae, Lepidostomatidae, Brachycentridae, Sericostomatidae
8	Astacidae Lestidae, Agriidae, Gomphidae, Cordulegasteridae, Aeshnidae, Corduliidae, Libellulidae, Psychomyiidae (Ecnomidae), Phylopotamidae
7	Caenidae Nemouridae Rhyacophilidae (Glossosomatidae), Polycentropodidae, Limnephilidae
6	Neritidae, Viviparidae, Ancylidae (Acroloxidae) Hydroptilidae Unionidae Corophiidae, Gammaridae (Crangonyctidae) Platycnemididae, Coenagriidae
5	Mesovelidae, Hydrometridae, Gerridae, Nepidae, Naucoridae, Notonectidae, Pleidae, Corixidae Haliplidae, Hygrobiidae, Dytiscidae (Noteridae), Gyrinidae, Hydrophilidae (Hydraenidae), Clambidae, Scirtidae, Dryopidae, Elmidae Hydropsychidae Tipulidae, Simuliidae Planariidae (Dogesiidae), Dendrocoelidae
4	Baetidae, Sialidae, Pisicolidae
3	Valvatidae, Hydrobiidae (Bithyniidae), Lymnaeidae, Physidae, Planorbidae, Sphaeriidae Glossiphoniidae, Hirudinidae, Erpobdellidae, Asellidae
2	Chironomidae
1	Oligochaeta Culicidae

Source: WHO (1996)

RESULTS

Macroinvertebrates

Checklist of macroinvertebrate species identified in Jakara Dam is shown in Table 2. A total of ten thousand six hundred and thirty one (10631) macroinvertebrates belonging to three phyla Mollusca, Arthropoda and Annelida, were identified. Mollusca had 5 families. These were Thiaridae, Viviparidae, Bithyniidae, Plarnobidae and Lymnaeidae. Arthropoda was represented by 8 families: Chronomidae, Simuliidae, Culicidae, Cordulidae, Tabanidae, Caenidae, Dytiscidae and Lestidae. Annelida had only 2 families which were Oligocheata and Hirudinidae. With regard to species identified, *Melanoides tuberculata* was found to have the highest number of occurrence with a total number of 6258 (58.86%), followed by *Chironomus* sp. with a total number of 2256 (21.22%), *Tubifex tubifex* with a total of 805 (7.57%), Mosquito larvae with a total number of 269 (2.53%), *Bithynia tentaculata* with a total number of 240 (2.26%), *Bellanya* sp. with a total number of 226 (2.13%), Macroinvertebrates with intermediate estimates were *Eisenneilla* sp. with a total of 178 (1.67%), *Bulinus nyassanus* with a total of 160 (1.51%), *Bulinus globosus* with a total of 117 (1.10%). The least occurred macroinvertebrates were the *Simulium* sp. with a total number of 1 (0.009%), damsel fly larvae and *Maoridiamesa* with total number of 2 (0.02%), *Caenis* sp. with total number of 3 (0.03%), *Hybomitra ciureai* with total number of 5 (0.08%), *Hirudo medicinalis* with total number of 24 (0.23%), *Onychohydrus hookerii* with a total number of 28 (0.26%), and *Stictocladius* with a total number of 38 (0.36%). Site B has the highest number of macroinvertebrates recorded with a cumulative number of 3000. Site C recorded the least total number of macroinvertebrates with a cumulative total number of 1735.

The monthly mean variations in BMWP and ASPT score are shown in Table 3. The monthly mean variations of BMWP score ranged from 6 in April to 44 in January. The monthly mean variations in ASPT score ranged from 2 in February and April to 4.2 in October. Analysis of variance revealed significant difference (P≤0.05) in BMWP Score and ASPT Score between the sites (Table 4).

Table 2: Check list of Macroinvertebrates Species Identified in Jakara Dam, Kano.

S/N	PHYLUM AND FAMILY NAMES	Site A	Site B	Site C	Site D	Total	%	BMWP Score
	Mollusca							
	Family:Thiaridae:							
1	*Melanoides tuberculata*	1644	1662	1154	1798	6258	58.86	3
	Family: Bithyniidae:							
2	*Bithynia tentaculata*	142	60	15	23	240	2.26	3
	Family: Viviparidae:							
3	*Bellamya sp.*	98	51	23	54	226	2.13	6
	Family*:*Planobidae *Bulinus*							
4	*globosus*	23	36	9	49	117	1.10	3
5	*Bulinus nyassanus*	89	31	9	31	160	1.51	3
	Family: Lymnacidae*:*							
6	*Lymnaea acuminate*	-	13	4	3	20	0.19	3
	Arthropoda							
	Family: Chironomidae							
7	*Chironomus* sp.	399	713	355	789	2256	21.22	2
8	*Stictocladius*	20	15	1	2	38	0.36	2
9	*Maoridiamesa*	-	1	-	1	2	0.02	2
	Family: Simuliidae:							
10	*Simulium* sp.	-	1	-	-	1	0.009	4
	Family: Culicidae							
11	Mosquito larvae	76	10	68	115	269	2.53	1
	Family:Cordulidae							
12	*Procordulia*	8	2	2	5	17	0.16	8
	Family: Tabanidae:							
13	*Hybomitra ciureai*	-	1	1	3	5	0.08	5
	Family: Caenidae							
14	*Caenis* sp.	-	2	-	1	3	0.03	7
	Family: Dytiscidae							
15	*Onychohydrus hookeri*	-	9	-	1	28	0.26	5
	Family: Lestidae							
16	Damselfly larvae	-	1	1	-	2	0.02	8
	Annelida							
	Family: Oligochaeta							
17	*Eisenniella* sp.	33	76	30	39	178	1.67	1
18	*Tubifex tubifex*	192	311	58	244	805	7.57	1
	Family: Hirudinidae							
19	*Hirudo medicinalis*	6	5	5	8	24	0.23	3

Total	2730	3000	1735	3166	10631	100	70

Table 3: Mean Monthly Values of (BMWP) and (ASPT) Between and Within Sites of Jakara Dam (January 2016 to October 2016)

	BMWP				ASPT			
Month	Site A±SE	Site B±SE	Site C±SE	Site D±SE	Site A±SE	Site B±SE	Site C±SE	Site D±SE
January	35±1.5	34±7.0	44±4.0	40±3.0	3.2±0.6	3.1±0.4	3.7±0.3	3.1±0.4
February	16±2.0	26±6.0	14±3.0	16±2.0	2.0±0.2	2.6±0.2	2.0±0.3	2.0±0.3
March	29±8.0	37±3.0	21±3.0	30±7.0	3.6±0.8	3.7±0.3	2.6±0.4	3.3±0.6
April	21±4.0	21±4.0	6.0±2.0	18±2.0	3.0±0.6	3.0±0.6	2.0±0.3	3.0±0.3
May	21±2.0	20±2.0	15±3.0	18±2.0	3.0±0.3	2.9±0.3	3.0±0.4	3.0±0.4
June	18±3.0	18±2.0	12±3.0	18±3.0	3.0±0.4	3.0±0.2	3.0±0.6	3.0±0.2
July	17±3.0	17±2.0	14±2.0	21±2.0	3.4±0.7	3.4±0.4	3.5±0.2	3.0±0.2
August	17±2.0	19±3.0	15±3.0	20±4.0	3.4±0.6	2.7±0.4	3.0±0.3	3.3±0.3
September	17±3.0	25±4.0	17±3.0	19±2.0	3.4±0.2	4.1±0.3	3.4±0.4	2.7±0.7
October	14±2.0	21±2.0	17±2.0	25±3.0	3.5±0.2	3.0±0.3	3.4±0.2	4.2±0.6
Mean	20.5±6.23	23.8±6.46	17.5±9.56	22.5±7.02	3.15±0.44	3.15±0.44	2.96±0.57	3.06±0.52

Table 4: Analysis of Variance (ANOVA) to Compare BMWP and ASPT Values Generated From Jakara Dam, Kano, Nigeria

Variable	f.	Df	p. value
BMWP	18.65	3	0.00
ASPT	6.395	3	0.01

DISCUSSIONS

Strzelec and Krolczyk (2004) indicated that many gastropod species are tolerant to many physico-chemical parameters and their occurrence is affected by the quality of bottom sediments and abundance of vegetation and most suitable substrate for snail in water is a sandy bottom covered with thin layer of organic silt. The abundance of *Melanoides tuberculata* was observed to be possibly favoured by the biotic and abiotic components prevailing in the dam. Garg *et al.* (2009) also attributed the richness of molluscs observed in Ramsagar Dam to be cumulative effect of alkaline nature of water. Supian and Ikhwanuddin (2002) reported that *M. tuberculata* is the commonest and most wide ranging member of family Thiaridae found in almost any kind of freshwater. Contreras-Arquieta (1998) reported that members of Thiaridae are quick colonizers, tolerant

to habitat diversity and variability due to a very strong and thick shell, many forms are parthenogenetic females capable of multiplication in a short time, viviparous and have average longevity of five years. *Bellamya* sp. occurs preferentially near the bank of the river or lakes where immerged plant and debris are abundant and represented good habitat for them (Leveque, 1979). This habitat preference could be the reason why they were not found in large number. *Bulinus globosus, Bulinus nyassanus*, *Bithynia tentaculata* and *lymnaea acuminata* were found to be present in all studied sites. Appleton

(1998) described lotic water environment as the most important factor for explaining the longitudinal distribution of snails that are the intermediate host of Schistosoma species. These species have potential to be good bioindicators of contamination (Desy *et al.,* 2000). Arthropoda appeared to be dominant in terms of family richness. This conforms with the findings of Mellanby (1997) that arthropods are adapted to life in diverse habitats due to their mode of feeding, behaviour, physiology and adaptation to the wide range of physico-chemical parameters. *Chironomus* sp. and *Tubifex tubifex* were also found to be dominant across the sites. These indicate high organic load in the dam. Mir and Yousuf (2008) stated that the nature of the sediment influences the population dynamics of the oligochaetes in lakes as dominant oligochaetes thrive well in sediments rich in organic nutrients. Armitage (1995) showed that high sediment load in aquatic environment favours the abundance of tolerant macroinvertebrate taxa such as *Oligochaeta* and *Chironomidae*. Study by Kaller and Hartman (2004) in seven Applachiam streams with different levels of sediment accumulation, showed consistent negative relationship with finest substrate particles (<0.25mm) that exceed 0.8-0.9% of riffle substrate composition and EPT sensitive taxa richness. In contrast to taxa such as Chironomidae, and Oligochaeta, which are associated with fine sediments. Similar study by Donohue and Irvine (2004) in Lake Tanganyinka, also found lower abundance of macroinvertebrate at the mouth of the Lanzua River due to significant higher sediment loads. Therefore, increased sediment deposits in the Jakara Dam might alter the substrate composition and cause the replacement of sensitive macroinvertebrate taxa with the tolerant macroinvertebrate taxa and subsequently lowering the BMWP scores and ASPT values. Usman (2015) reported that waterfowl contribute to the degradation of water quality. Based on physical observation made during the study period, presence of waterfowl in the Dam might have contributed to the addition of nutrients to the water which may cause nutrient enrichment and subsequently the abundance of tolerant taxa which resulted in decrease in BMWP/ASPT values in the Dam. This was also supported by Manny *et al.* (1994), who found that bird faeces at Wintergreen Lake in Michingan have led to degraded water quality through the addition of estimated 27 percent nitrogen and 70 percent of phosphates. On the basis of adopted BMWP Score and ASPT Criteria, a BMWP Score greater than 100, together with an ASPT value greater than 4, generally indicates good water quality (Bartram and Ballance, 1996). Looking at the monthly mean values of BMWP and ASPT Score (Table 2), BMWP Scores were less than 100 and ASPT Scores also were less than 4. The monthly mean values obtained from the study therefore indicate poor water quality. The overall assessment based on indicator organisms showed that the Jakara Dam was of poor water quality. The presence/ dominance of these pollution indicator macroinvertebrates in the dam comfirmed that Jakara Dam was of poor water quality.

CONCLUSION AND RECOMMENDATIONS

Jakara Dam was of poor water Quality. Presence of pollution indicator macroinvertebrates such as *Tubifex tubifex*, *Chironomus* sp., *Melanoides tuberculata*, *Eiseniella* sp., *Hirudo* *medicinalis*, *Bithynia* sp., showed alarming shift or total elimination of sensitive biotic community from the Dam. Direct discharge of untreated sewage and effluents from Kano city's domestic and industrial wastes via River Jakara and agricultural run-off from surrounding farmlands had much effect on the general condition of the Dam. It is therefore recommended that further studies should be done to validate the use of BMWP/ASPT score as indices of organic pollution, and there is need of consistent internationally recognized data driven strategy to assess the water quality of Jakara Dam so as to save the life of Jakara Dam fishes and other living organisms there in.

Competing Interest

The authors declare that they have no competing interest.

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